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Resolving deformation-induced fracture processes at the slow-moving Heumoes slope by permanent seismic monitoring

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Applying the method Nanoseismic Monitoring to the slow moving Heumoes slope, Austria, which consists of weak sediments, a permanent network of three seismic small-arrays was installed in July 2009 in order to determine the spatio-temporal occurrence of varying slope dynamics. Beside fracture processes caused by initial stress relief in the slope's subsurface, which were also recorded during several field-campaigns between 2005 and 2008, we observed new, unexpected signals caused by superficial frost-shattering at the beginning of frost-periods. During the winter 2009/2010, the soil-temperature was permanently below 0 °C for a time-period of $\sim$60 days, which led to a maximum frost penetration depth of more than 1 m. These frost heaves mark water paths, along which fast water infiltrations take place during the snow-melting periods. Comparable to macropores, where fast water-infiltrations take place during the summer-time, these frost heaves cause a significant raise of displacements at the estimated shear-plane in a depth of $\sim$11 m, measured by inclinometer devices.

In contrast to the seismic events caused by frost-shattering, we observed more than 70 fracture processes caused by initial deformation processes of the unstable slope material itself. Their temporal occurrence correlates well with the snow-melting periods in spring and strong rainfall-events in summertime and do not correlate with higher temporal displacement rates in the subsurface. As the unstable Heumoes slope consists of weak sediments, the generation of measurable fracture processes or stress relief takes place as a function of the water saturation of the slope material. We therefore assume, that the inclinometer devices observe the flow of the slope when the material is nearly water-saturated, while the fracture processes occur when the water saturation of the slope material decreases.

Additional geophysical investigations, like ERT and active seismic measurements, show that the areas where most of the fractures are located are dominated by a raise of the bedrock topography in the subsurface. These areas obviously cause an accumulation of tension resulting in higher stress relief compared to areas where the slope material is minor influenced by the bedrock topography and can flow without any barriers.

The focus of this study is, beside the analysis of the spatio-temporal occurrence of the observed seismic signals, their interaction, signal classification criteria as well as results from additional field experiments, the analysis of slope material deformations in dependence of its water saturation. The embedding of these results in the comprehensive model of the complex behaviour of the entire Hemoes slope will be presented.